

## CLAIMS

### What is claimed is:

1. A semiconductor device structure having a homogenous aluminum alloy material within contact holes in an insulating layer overlying a substrate, the semiconductor device structure formed by the method comprising:
- 5 depositing an aluminum material on an exposed surface of the insulating layer and over the contact holes;
- heating the aluminum material to reflow the aluminum material into the contact holes so as to at least partially fill the contact holes;
- 10 applying pressure to the aluminum material to completely fill the contact holes;
- depositing a different metal material on the aluminum material over the contact holes; and
- diffusing the different metal material into the aluminum material to form a homogeneous aluminum alloy fill material in the contact holes.
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2. The semiconductor device structure of claim 1, wherein depositing an aluminum material comprises physical vapor deposition of the aluminum material.
3. The semiconductor device structure of claim 1, wherein heating and applying pressure to the aluminum material are executed simultaneously.
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4. The semiconductor device structure of claim 1, wherein heating the aluminum material comprises heating the aluminum material with a heater.
5. The semiconductor device structure of claim 4, wherein the aluminum material is heated to about 400°C.
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6. The semiconductor device structure of claim 1, wherein heating the aluminum material comprises irradiating the aluminum material with argon plasma.

7. The semiconductor device structure of claim 1, wherein heating the aluminum material comprises simultaneously heating the aluminum material with a heater and irradiating the aluminum material with argon plasma.

5 8. The semiconductor device structure of claim 1, wherein applying pressure comprises introducing the semiconductor device into a high pressure chamber and pressurizing the high pressure chamber.

10 9. The semiconductor device structure of claim 8, further comprising maintaining the temperature within the high pressure chamber at about 400°C.

10. The semiconductor device structure of claim 8, wherein the high pressure chamber is pressurized to more than 500 atm.

15 11. The semiconductor device structure of claim 1, wherein depositing a different metal material comprises physical vapor deposition of the different metal material.

20 12. The semiconductor device structure of claim 1, wherein depositing a different metal material comprises vacuum evaporation deposition of the different metal material.

25 13. The semiconductor device structure of claim 1, wherein the different metal material comprises a metal alloy.

14. The semiconductor device structure of claim 1, wherein the different metal material comprises a substantially pure metal.

15. The semiconductor device structure of claim 14, wherein the substantially pure metal comprises copper.

5 SUB D17 16. The semiconductor device structure of claim 15, wherein the copper is deposited on the aluminum material through an electroless plating process.

17. The semiconductor device structure of claim 14, wherein the substantially pure metal comprises nickel.

18. SUB D21 18. The semiconductor device structure of claim 17, wherein the nickel is deposited on the aluminum material through an electroless plating process.

15 19. The semiconductor device structure of claim 1, wherein diffusing the different metal material comprises heating the different metal material to diffuse the different metal material into the aluminum material.

20 20. The semiconductor device structure of claim 19, wherein heating the different metal material comprises irradiating the different metal material with argon plasma.

21. The semiconductor device structure of claim 19, wherein heating the different metal material comprises simultaneously heating the different metal material with a heater and irradiating the different metal material with argon plasma.

25 22. The semiconductor device structure of claim 1, wherein diffusing the different metal material comprises annealing the different metal material to diffuse the different metal material into the aluminum material.

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23. A semiconductor assembly formed by the method comprising:  
providing a semiconductor substrate having an insulating layer overlying the  
semiconductor substrate, the insulating layer having contact holes formed  
therein;  
simultaneously depositing and heating an aluminum material on an outer surface of  
the insulating layer and over the contact holes;  
applying pressure to the aluminum material to completely fill the contact holes;  
depositing a different metal material on the aluminum material; and  
diffusing the different metal material into the aluminum material to form a  
substantially homogeneous aluminum alloy fill material in the contact holes.

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24. The semiconductor assembly of claim 23, wherein depositing an aluminum  
material comprises physical vapor deposition of the aluminum material.

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25. The semiconductor assembly of claim 23, wherein heating the aluminum  
material comprises irradiating the aluminum material with argon plasma.

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26. The semiconductor assembly of claim 23, wherein heating the aluminum  
material comprises simultaneously heating the aluminum material with a heater and  
irradiating the aluminum material with argon plasma.

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27. The semiconductor assembly of claim 23, wherein applying pressure  
comprises introducing the semiconductor device into a high pressure chamber and  
pressurizing the high pressure chamber.

28. The semiconductor assembly of claim 27, further comprising maintaining  
the temperature within the high pressure chamber at about 400°C.

29. The semiconductor assembly of claim 27, wherein the high pressure chamber is pressurized to more than 500 atm.

30. The semiconductor assembly of claim 23, wherein depositing a different metal material comprises physical vapor deposition of the metal material.

31. The semiconductor assembly of claim 23, wherein depositing a different metal material comprises vacuum evaporation deposition of the different metal material.

32. The semiconductor assembly of claim 23, wherein the different metal material comprises a metal alloy.

33. The semiconductor assembly of claim 23, wherein the different metal material comprises a substantially pure metal.

34. The semiconductor assembly of claim 33, wherein the substantially pure metal comprises copper.

35. The semiconductor assembly of claim 34, wherein the copper is deposited on the aluminum material through an electroless plating process.

36. The semiconductor assembly of claim 33, wherein the substantially pure metal comprises nickel.

37. The semiconductor assembly of claim 36, wherein the nickel is deposited on the aluminum material through an electroless plating process.

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38. The semiconductor assembly of claim 23, wherein diffusing the different metal material comprises heating the different metal material sufficiently to diffuse the metal material into the aluminum material.

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39. A semiconductor assembly having an aluminum-containing material within contact holes in an insulating layer overlying a substrate, the semiconductor assembly formed by the method comprising:

providing a semiconductor substrate having a dielectric layer overlying a semiconductor substrate, the insulating layer having contact holes extending therethrough;

filling the contact hole with a metal material including aluminum as a major constituent; and

modifying the characteristics of the metal material by diffusing at least a second metal material thereinto.

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40. The semiconductor assembly of claim 39, wherein the metal material comprises an alloy containing aluminum and at least one metal selected from the group consisting of copper, silver, zinc, nickel, and tin.

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41. The semiconductor assembly of claim 39, wherein the second metal material is selected from the group consisting of copper, silver, zinc, tin, nickel, and magnesium.

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42. The semiconductor assembly of claim 39, wherein filling the contact hole comprises physical vapor deposition of the metal material.

43. The semiconductor assembly of claim 39, further comprising depositing at least one second metal material onto the metal material through physical vapor deposition.

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44. The semiconductor assembly of claim 39 further comprising depositing at least one second metal material onto the metal material through vacuum evaporation deposition.

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